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CITY OF ALAMEDA  
AIRPORT SAFETY  
A PART OF THE GENERAL PLAN  
SAFETY ELEMENT

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Prepared by  
[ ENVICOM CORPORATION ]

ADOPTED BY CITY COUNCIL, SEPTEMBER 21, 1976



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On July 15, 1975, the Alameda City Council authorized Envicom Corporation to proceed with studies for the preparation of a Seismic Safety and Safety Element, in accordance with California Government Code Sections (65302(f)), 65302.1, and 65302.2, as part of the City's General Plan. Work performed by Envicom Corporation under that agreement has been summarized in two volumes, the Draft Seismic Safety and Safety Element Technical Report and Draft Seismic Safety and Safety Element Policy Report. These two volumes are under review by the appropriate agencies at this time.

Subsequent to that initial agreement, on January 7, 1976, the Alameda City Council authorized Envicom Corporation to proceed with additional studies of airport related safety hazards in the City for inclusion as part of the General Plan Safety Element. This single volume report, the Draft Airport Safety Study, summarizes the work performed by Envicom Corporation in accord with this latter agreement. This documentation of studies is intended for incorporation into the General Plan Seismic Safety and Safety Element after review, and for submission for approval and adoption by the City of Alameda.





## I. INTRODUCTION

### A. PURPOSE AND SCOPE

With over a dozen airports in a relatively small area conducting more than eight thousand operations a day, the San Francisco Bay Area has one of the busiest air spaces in the nation. Two of the largest airports, Oakland International Airport and Alameda Naval Air Station (NAS), are located adjacent to and in the City of Alameda, respectively. Because of the proximity of these airports to populated areas of the City, the issue of airport safety is included in Alameda's General Plan Safety Element.

The Safety Element is one of the State-mandated Elements required of all local government General Plans. State guidelines governing preparation of the Safety Element limit its scope primarily to analysis of natural hazards, specifically fire and flood hazards. The guidelines are not exclusive, however, and permit analysis of other hazards relevant to individual jurisdictions. Alameda's location with respect to Oakland Airport and NAS Alameda, and the risk of take-off and landing air crashes, creates a somewhat unique potential hazard in the City. Land-use planning is an appropriate and effective community response to this type of hazard, and the purpose of this report, as part of the Safety Element, is to introduce airport safety as a consideration in Alameda's land-use planning process.

In meeting this purpose, the analysis contained herein attempts to determine the likelihood of an air crash in the City, its most probable location, and the extent of damage and casualty risk it poses to the community. The analyses of these factors, or risk criteria, are presented in Part II, the Technical Analysis. Based on these criteria, the report suggests alternative land-use and density policies to minimize the loss of life and property in the event of an air crash in Alameda.

## B. APPROACH

An aircraft crash is an extremely complex, rapid event whose final impact is dependent upon a large number of human, mechanical, and land use factors. In general, there are two approaches to analyzing such an event. The first is a qualitative approach that seeks to explain groups of possible cause-and-effect relationships that can result in a crash. By identifying the causes of accidents, including human factors, this approach identifies the areas in which accident reduction measures can be taken. Such an approach is typified by questions such as "What are typical safety problems encountered in the various phases of a flight?" and "What steps can a pilot take if he finds his aircraft in trouble?" The second approach is more quantitative and seeks to analyze large groups of accident data for the purposes of probability analysis. This approach treats an accident as a reasonably predictable event, given certain data, and seeks answers to questions such as "What is the most probable location of a crash?", "How many accidents can a 'typical' general aviation



airport expect each year?", and "What size ground area can expect to be impacted by a crash?" The basis of this approach is reliance on past data to predict future accidents, and thereby facilitate action to minimize crash impacts in areas of expected accidents.

It is important to note in discussing these two approaches that most studies are neither wholly qualitative nor wholly quantitative. Elements of both types appear in almost all airport safety studies. The reason for this is important - there is no single, objective methodology for conducting an airport safety analysis. All studies rely to a large extent on individual judgment based on experience with airport safety. This is evidenced in this report by the use of two different methodologies for the two airports under study. Aircraft accident potential near NAS Alameda was analyzed using the Accident Potential Zone (APZ) program developed by the Department of the Navy. Accident potential near Oakland Airport was analyzed using a methodology based on studies by McElroy (1973), Garbel (1973), the City of Inglewood (1974), and the National Transportation Safety Board (1973). All of these methodologies treat an aircraft accident in both a qualitative and quantitative way. They are quantitative because it is necessary to provide some measureable criteria for making decisions about acceptable risk. They are qualitative because they involve making a judgment, either implicit or explicit, about risk. The numbers used in this report, then, should not be thought of as precise measures. Rather, they should be treated as general,

order-of-magnitude estimates that can be used in making risk judgments.

Finally, it is important to state the underlying assumption used in this report's approach. This study has been prepared for the City of Alameda for land-use planning purposes. The primary safety concern of this report, then, is the safety of people on the ground rather than the safety of people in aircraft. The two are closely interrelated, of course, in that both the pilot and the person on the ground have a better chance of survival if an aircraft in trouble can be brought down in an unpopulated area. However, a land use which minimizes the risk to the ground population does not necessarily minimize the risk to the pilot and passengers. In this report, reducing the hazard potential for the ground population is given first consideration.



## II. TECHNICAL ANALYSIS

### A. GENERAL STATEMENT

Air travel is one of the greatest achievements of the technology of this century. It makes for a convenience and mobility that is a central part of the life style of industrial nations. Like other technological advances, though, air travel creates hazards which are part of the cost of increased mobility. The safety record of aircraft is one of the best of any transportation mode, however, and aircraft accident rates continue to decline. Aircraft accidents, especially accidents involving large air carriers, may be thought of, then, as low probability events comparable to large dam failures, catastrophic spills of toxic chemicals, and nuclear reactor melt-downs. In terms of casualty risk, the odds of an Alameda resident dying as the result of a plane crash on his property are very low compared to the risks posed by other types of accidents. The approximate annual risk rate of death resulting from automobile accidents is 26.6 per 100,000 persons. Work accidents have a risk rate of 19.0 per 100,000 persons, and home accidents have a risk rate of 14.3 per 100,000 persons (1). In contrast, calculations based on the probability of a large twin-engine plane crash yield a risk rate to Alameda residents of about 0.5 deaths per 100,000 persons exposed. Data supplied by the FAA (San Francisco District Office) indicates that from 1950 to 1963, the ratio between non-occupant fatalities resulting from aviation accidents and automobile accidents was .00054. Thus, the probability of persons not in the airplane dying in a crash is quite low. What makes safety planning around airports worthwhile is that, if the probability is realized, it is likely that the single event



will result in high consequences.

The risk of an aircraft accident in the City of Alameda is analyzed in this report in this context. An aircraft accident is a low probability, high consequence event. While the risk of such an event is implicitly accepted by those who choose to fly, the general public may be less aware of the potential hazard to those living in the vicinity of airports. The technical analyses of this section are an attempt to identify the risk to ground populations in the City of Alameda in a way such that acceptable risk decisions can be made.

## B. METHODOLOGIES

### 1. Background and Definitions

As noted in the introductory section on the approach of this report, there is no single, objective methodology for evaluating the risk of an aircraft crash. In preparing this report, a number of different methodologies for designating accident risk areas were studied, including the airport safety studies prepared by Orange and Santa Clara Counties and the City of Inglewood, the Doolittle Report, and APZ guidelines, and the work done by Garbell, McElroy, and Solomon et al. Two different methods were selected as being most appropriate to the two different types of airports under consideration.

Oakland Airport consists of two runway complexes. The complex of concern to the City is the North Airport Runway 27 complex because straight-out take-offs from this complex fly over existing residential development in the Bay Farm Island area - a peninsula shared by Oakland International Airport. The two preferential runways in



the complex are used primarily by light single or twin reciprocating general aviation aircraft, and by a small number of light turbo-prop aircraft. The port of Oakland recently adopted a policy banning jets, heavy turbo-prop aircraft, and reciprocating four-engine aircraft from using the Runway 27 complex, except in emergencies. The method used in evaluating accident potential near these runways is a synthesis of the work by Garbell, McElroy and the City of Inglewood, using data compiled by the National Transportation Safety Board.

Alameda Naval Air Station has two runways, both of which are used by a variety of military aircraft ranging from attack jets to helicopters. A methodology has been developed by the Department of the Navy specifically to evaluate the potential for aircraft accidents near military airports. This methodology, termed the Accident Potential Zone (APZ) Program, has been used by Navy staff to analyze accident potential at NAS Alameda, and is incorporated in this report.

Both of the methods used in this analysis share common terminology in describing airport operations. The following paragraphs define some of the basic terms used.

Runways are designated at an airport by numbers from 1 to 36 which correspond to the magnetic heading of the runway (to the nearest 10 degrees). Thus, each single airstrip comprises two runways with headings differing by 180°. For example, a runway with magnetic heading of 293° is designated R 29, and the same runway in the opposite direction, with a heading of 113°, (i.e., 293°-180°), is designated R 11.



An operation is the term applied to either a single take-off or a single landing, and the number of operations is an indicator of the size and activity of an airport. Operations are often broken down into categories by type of aircraft and the purpose of the flight. For example, air carrier operations are commercial airline operations and most often involve larger jets and piston-powered aircraft. General aviation operations involve civilian aircraft which are primarily single and twin-engine light aircraft used for business, personal transportation, and pleasure flying.

All airports are assigned a three-letter mnemonic by the FAA related to the airport name. Oakland Airport is OAK, Alameda Naval Air Station is NGZ, and San Francisco International is SFO.

Two sets of Federal Aviation Regulations apply to flying at these (and all) airports. They are Visual Flight Rules (VFR), which are used normally during conditions of good visibility, and Instrument Flight Rules (IFR), which are usually used in inclement weather and at night. VFR application is possible at night, though, and IFR may be used in good weather. IFR requires precision maneuvering based on constant contact with air traffic controllers on the ground through a complex set of electronic navigation instruments in the aircraft and navigation aids on the ground. Most approaches and departures by general aviation aircraft are under VFR in the Bay Area in good weather, but all air carrier operations are conducted under IFR in good and bad weather. Thus, air carrier traffic flows along prescribed routes



known as Standard Instrument Departures (SID's) and Standard Terminal Arrival Routes (STAR's), and are constantly monitored by radar at NGZ, OAK, SFO, and a central FAA control facility called TRACON which is located at OAK. These routes are designated by name and a number. For example, the major SID's from Oakland's Runway 29 are called Napa Five, Drake Three, College Five, and Portola Seven (2).

## 2. Risk

The purpose of this technical analysis is to identify those criteria which can be used in making decisions about risk. The Council on Intergovernmental Relations defines risk in three categories:

1. Acceptable Risk: The level of risk below which no specific action by government is deemed to be necessary.
2. Unacceptable Risk: The level of risk above which specific action by government is deemed to be necessary to protect life and property.
3. Avoidable Risk: A risk which need not be taken because individual or public goals can be achieved at the same, or less total "cost" by other means without taking the risk (3).

As is the case with natural hazards, such as earthquakes and fires, determining levels of acceptable risk from air crashes is a process intended to answer the question, "How safe is safe enough?" The same kind of criteria used in natural hazards can be used in defining risk from aircraft accidents. These criteria are magnitude, frequency, and location. The magnitude of the event refers to its size. Examples are the rating of an earthquake on the Richter scale, the height of flood waters, or the



number of acres burned in a wildland fire. In terms of an aircraft accident, magnitude can be measured by the size of the area affected by the crash, the number of non-occupant deaths and injuries, or the amount of structural damage. Frequency refers to the number of times an event occurs during a certain period of time. The relationship between frequency and magnitude is inverse in natural hazards. That is, the less often an event occurs, the greater is its size and impact. Analysis of accident data indicates that this same relationship holds for air crashes, although not for any inherent natural reason. Aircraft accidents are basically a function of the number of operations and the prevailing accident rate. Because there are many times more general aviation operations than air carrier operations, general aviation low magnitude events occur more often than high consequence air carrier accidents (4).

These three criteria - magnitude, frequency, and location - can be used in making judgments about acceptable risk by relating them to land use and density policies. For example, one or two general aviation accidents every three years may be considered acceptable for a given density of development, while a single air carrier accident every ten years may be considered unacceptable for that same density. This relationship between risk criteria and development policies is discussed more fully in the following analyses of Oakland Airport and Alameda Naval Air Station and in Section III, Policy Recommendations.



## C. OAKLAND AIRPORT

### 1. Operations

The Oakland Airport (OAK) is operated by the Port of Oakland and is the principal air carrier airport serving the East Bay counties. San Francisco International Airport (SFO) serves the communities on the west side of the Bay in Marin County and on the San Francisco peninsula. SFO also serves as the major regional airport in Northern California for long haul overseas flights. Air traffic from both of these facilities flies over the City of Alameda (5), but for purposes of airport safety planning, traffic from OAK only is considered in this report. This is because of the proximity of OAK to Alameda and the fact that most accidents occur within one mile of the runway, as discussed in Section 3.

The great majority of operations at OAK are general aviation activities using the North Airport Complex. This complex consists of six runways (three airstrips): 27R, 27L, 9R, 15, and 33. The runways used most often are 27R and 27L.

The South Airport complex comprises two runways, 29 and 11. This airstrip is used primarily by air carrier type planes typified by light to medium jet carriers such as the Boeing 727 and 737. Heavier aircraft, such as Boeing 747 or DC-10, do not normally operate out of OAK since they are used for longer flights operating out of SFO (6). Table 1 provides a summary of the number and type of operations for both runway complexes for 1974.

Flight patterns at Oakland Airport vary according to which runway is used and the destination of the aircraft. Those patterns

TABLE 1

SUMMARY OF ANNUAL OPERATIONS, 1974  
OAKLAND AIRPORT

| Runway Complex                                 | Operation Category | Annual Operations |
|------------------------------------------------|--------------------|-------------------|
| 11-29<br>(South Airport)                       | Air Carrier        | 55,742            |
|                                                | Air Taxi           | 1,620             |
|                                                | Civil Itinerant    | 6,391             |
|                                                | Military Itinerant | 915               |
|                                                | Civil Local        | 15,045            |
|                                                | Military Local     | <u>2,243</u>      |
| Subtotal:                                      |                    | 81,956            |
| 27R, 27L,<br>9R, 9L, 15, 33<br>(North Airport) | Air Carrier        | 1,104             |
|                                                | Air Taxi           | 5,140             |
|                                                | Civil Itinerant    | 126,047           |
|                                                | Military Itinerant | 1,008             |
|                                                | Civil Local        | 128,293           |
|                                                | Military Local     | <u>556</u>        |
| Subtotal:                                      |                    | 262,148           |
| Total:                                         |                    | 344,104           |

Source: Port of Oakland (7).



which are of importance to the City of Alameda are take-offs from Runways 29, 27R, 27L, and 33, and landings on Runways 11, 9R, 9L, and 15. These are the patterns which result in flights near or directly over the City. For purposes of airport safety planning, the principal concern is with flight patterns that take an aircraft over land within one mile of the end of the runway. The reason for this delimitation, as discussed in the following section on the probable location of air crashes, is that most accidents occur within a mile of the runway. Accordingly, operations on Runways 29 and 11 do not pose a significant hazard to Alameda since these operations are almost exclusively over water. There is one Standard Instrument Departure (SID) route from Runway 29 which leads northeast over the City. This route is designated "College Five" and leads over the northwestern portion of Alameda over the Naval Air Station (8). Since this overflight occurs at a distance beyond one mile from Runway 29, it is not considered significant in terms of safety planning.

The most important runways in terms of safety are Runways 27R, 27L, 9R, and 9L in the North Airport complex. Operations on Runways 33 and 15 fly over either airport property or the waters of San Leandro Bay within a mile of the runway, and do not present a significant hazard. The potential safety problems associated with the North Airport are further mitigated by the presence of the Alameda Municipal Golf Course, located to the northwest at the end of Runways 29R and 29L. During normal general aviation activity, the flight pattern calls for a slight right turn after take-off which routes the aircraft over the golf course. The most significant safety problem arises when heavier aircraft or any aircraft operating under IFR, use a straight-out take-off pattern



which takes them over existing residences and land zoned for residential use. A first step in mitigating this problem was recently taken by the Port of Oakland by adopting a policy banning jets and heavier aircraft from using Runways 27R and 27L.

On March 17, 1976, for reasons of noise abatement, the Port of Oakland Board of Commissioners adopted a policy prohibiting take-offs from Runways 27R and 27L and landings on Runways 9R and 9L by the following types of aircraft: (1) turbojet and turbo-fan powered aircraft, (2) turbo-prop powered aircraft with a certified gross take-off weight over 12,500 pounds, and (3) all four engine reciprocating engine aircraft (Resolution No. 23150). These aircraft are directed by the Port's resolution to use Runway 29-11 except in emergency situations or whenever Runway 29-11 is closed for maintenance or construction.

This policy has an important effect on safety planning in the vicinity of the airport because it is the heavier aircraft which have the highest consequences in the event of a crash in terms of casualties of people on the ground. By prohibiting the types of aircraft listed above from taking off or landing in patterns which fly over existing homes on Bay Farm Island, the Port has reduced the risk of a high consequence crash there. Those aircraft types which can still fly over Bay Farm Island are all single and twin reciprocating engine aircraft and turbo-prop aircraft with a certified gross take-off weight of 12,500 pounds or less.



These aircraft should only fly over Bay Farm Island residences when they are operating under IFR. Under VFR, they are instructed to turn right and depart over the golf course.

Estimates of the number of straight-out take-offs from Runways 27R and 27L have been tabulated from operations data compiled by the Federal Aviation Administration. Operations records provided by the Port of Oakland for the first quarter of 1976 (January through March) show 1713 IFR departures originating at the North Airport complex. In using this sample as a basis for estimating straight-out departures, one important qualification must be noted. Some of the aircraft included in the estimate of straight-out departures may not have actually departed from Runway 27R or 27L. Available information indicates only that certain aircraft originated at the North Airport; they may have taxied to Runway 29-11 for take-off rather than use Runway 27R or 27L. This possibility is important because a number of the aircraft listed in the records are jets and heavy turboprop aircraft. Had these aircraft taken-off from Runway 27R or 27L after March 18, they would have violated the Port's adopted ban. In at least one instance, the departure of an Air California Boeing 737 on March 30, the record is known by Port staff to be in error. Port of Oakland staff are currently working to develop an accurate monitoring and reporting system to enforce the new ban. Once these matters are resolved, this report should be reviewed and revised if necessary. For the general planning purposes of this document, estimates of North Airport operations based on the existing data are offered at this time.



The recorded 1713 IFR departures from the North Airport occurred over a 91 day period. This yields an average of 18.82 departures per day and an annual average of 6870 IFR departures (about 3% of total North Airport Operations). As is discussed under the topic of accident magnitude, the type and weight of aircraft using the Runway 27 complex is an important factor in evaluating risk. The following distribution of aircraft types using Runway 27 was derived from the sample data:

| <u>Aircraft Type</u>                                    | <u>Percent of Runway 27<br/>IFR Departures</u> |
|---------------------------------------------------------|------------------------------------------------|
| Single engine, reciprocating                            | 51%                                            |
| Twin engine, reciprocating                              | 31%                                            |
| Twin engine, turboprop                                  | 8%                                             |
| Twin engine, jet                                        | 9%                                             |
| Three and four engine jets<br>and four engine turboprop | 1%                                             |
|                                                         | <u>100%</u>                                    |

At this table shows, most aircraft (82%) flying straight-out over existing residences on Bay Farm Island during the first quarter of 1976 were small, general aviation aircraft with one or two engines. The great majority of these aircraft weigh less than 12,500 pounds and fall into FAA weight category "small."

Since adoption of the Port's resolution banning jets and heavy aircraft, use of the IFR pattern from the Runway 27 complex is limited almost exclusively to these lighter types of aircraft. The only heavy aircraft that are currently allowed to take-off or approach over the homes on Bay Farm Island are those which are single or twin reciprocating engine aircraft. These aircraft are typified by older transport type aircraft such as the McDonnell-Douglas twin engine DC-3, and make up less than 1% of single



and twin-engine straight-out departures from Runway 27.

## 2. Accident Frequency

### (a) Existing Conditions

No environment, natural or urban, is hazard free. There is always some degree of risk in all human and natural systems, and transportation systems are no exception. One of the most significant factors in determining whether risks associated with a particular system are acceptable is the frequency or recurrence of hazardous events.

In air travel, accidents are a function of many interrelated factors. Some of these include time of day, experience of the pilot, condition of the aircraft, and the phase of flight. A host of other causative factors figure into accident analysis, but for general statistical purposes, these factors combine to result in an accident rate. Accident rates vary from airport to airport and from year to year. Generally, the trend has been lowering accident rates over the years. This trend is counter-balanced, however, by the large growth in the number of general aviation operations in recent years. Thus, while accident rates are decreasing, the number of annual operations is increasing. So, the potential exists for the total number of accidents to remain the same or actually increase. These two factors, the accident rate and the number of operations, are the prime factors determining the frequency of accidents, and can be used in estimating future accident potential. The accident rate used in estimating accident frequency for Oakland Airport was developed



from an analysis of 1970 data by McElroy (9). That analysis yields an accident rate of 1.38 accidents per million operations involving civil aircraft within a one-mile radius (excluding on-airport accidents) of airports with air traffic control towers. This accident rate is applicable in estimating accident probabilities near Oakland Airport since OAK is a tower-controlled, civilian airport. The principal sources of error in applying this national rate to Oakland Airport lie in its generalized nature and in its use for predicting very far into the future. It is recognized that accident rates vary according to whether the aircraft is departing or approaching, what weather conditions are, what type of aircraft is under consideration, and what the operating characteristics of the airport are. For general planning purposes, though, use of the gross accident rate is clearer and should be sufficient for risk-decision making. In addition, accident rates can be expected to change, and this has a major impact on frequency estimates. The use of this particular rate, then, is intended to provide only order-of-magnitude estimates of accident frequency. As a final note, analysis of the accident rate at Oakland alone is considered to be of limited value, and is not used in this analysis. The number of accidents at any one airport usually yields too small a sample to use as a predictive measure.

An accident rate of 1.38 per million operations breaks down to one accident per approximately 725,000 operations. To determine the expected accident frequency near an airport, it is necessary to know the time period during which this number of operations will occur. Projecting that the existing level of



activity at OAK will continue for at least the near future results in the following:

No. of operations per accident  $\div$  No. of annual operations =  
accident recurrence interval (years).

For total OAK operations:

$$725,000 \div 344,000 = 2.1 \text{ years}$$

This means that approximately every two years, on the average, one aircraft accident can be expected to occur within a one-mile radius of one of the runways at OAK. In breaking down airport operations further, the Runway 29-11 complex can expect one accident every 8.8 years, and the North Airport can expect one accident every 2.7 years. The most important application of the accident rate, however, is to the straight-out departure operations on Runways 27R and 27L. Because of the very low number of operations using the straight-out pattern, there is a corresponding low probability of a crash of one about every 105 years. This is clearly several orders of magnitude lower than for OAK as a whole, or for the North Airport as a whole.

In dealing with this low level of probability, the chief source of error is the projection of existing levels of activity into the distant future. It is important to remember, then, that this factor is a statistical indicator that can change as the accident rate and number of operations changes. It is also important to note that aircraft accidents are essentially random phenomena. This means that even though the recurrence interval for an accident is 105 years, there is nothing to prevent two 105 year accidents from occurring two years in a row. The prob-



ability of this happening is very low, of course, but it is a possibility.

Use of this type of recurrence interval is limited, then, by the following conditions: (1) it is a general statistical indicator of the probability of an event rather than a precise predictive measure, and (2) it is an indicator that can change with time as the accident rate and number of operations change. Even with these limitations, this estimate of accident frequency is a useful factor in making judgments about acceptable risk for the near future in the context of general planning. More specific data would give a refined estimate of accident frequency, but the general conclusion would most likely be the same: the crash of an aircraft, especially a large aircraft, into the existing Bay Farm Island residences is an unlikely event, but one worth planning for in the long term because of the high consequences.

#### (b) Future Conditions

In addition to the constraints imposed by unknown future changes in accident rates, prediction of accident frequencies for Oakland International Airport is limited by the fact that projections data for future operations of the Airport are not available (10). Accordingly, any prediction of future accident rates for Oakland Airport rests entirely on assumptions. Since general plans are intended to offer alternative views of the next twenty years, the following calculations are provided to meet that planning function. These calculations are based only on the following assumptions: (1) accident rate decreases of 25%, 33%, and 50%, and (2) operations increases of 20%, 60%, and 100%. These assumptions yield nine permutations or "alternative futures"



for any given existing case. For simplicity, the only case explored in the following table is that of straight-out departures from Runway 27R and 27L. The assumed increases in operations and decreases in accident rates use the existing parameters of 6870 operations and 1.38 accidents per million operations as their starting points.

TABLE 2

ALTERNATIVE FUTURE ACCIDENT RECURRENCE  
INTERVALS STRAIGHT-OUT DEPARTURES,  
RUNWAYS 27R and 27L  
OAKLAND INTERNATIONAL AIRPORT

| Assumed Operations Increase | Assumed Accident Rate Decrease | Estimated Accident Recurrence Interval |
|-----------------------------|--------------------------------|----------------------------------------|
| 20%                         | 25%                            | 116 years                              |
| 20%                         | 33%                            | 131 years                              |
| 20%                         | 50%                            | 175 years                              |
| 60%                         | 25%                            | 88 years                               |
| 60%                         | 33%                            | 98 years                               |
| 60%                         | 50%                            | 132 years                              |
| 100%                        | 25%                            | 70 years                               |
| 100%                        | 33%                            | 79 years                               |
| 100%                        | 50%                            | 105 years                              |

The most important two things that this table shows are that (1) the probable trends assumed in the calculations do not result in widely varying accident recurrence intervals, and (2) the recurrence intervals are not significantly different from the recurrence calculated for existing conditions.

These conclusions lend support to the use of an accident recurrence interval of about 100 to 200 years as one of the factors in making judgments about acceptable risk in the context of long-



term general planning.

### 3. Accident Location

The results of aircraft accident surveys conducted over the years clearly indicate that crash probability increases during landing as the plane approaches the runway, and decreases during take-off as the plane leaves the airport vicinity (11). The reasons for this are many, but can be summarized by saying that the "stress" on pilot and aircraft is greatest during the initial and final phases of flight. If an aircraft's power plant is going to fail, it is most likely to fail under maximum power during take-off when the aircraft is at maximum weight with a full fuel load. The highest stress phase of flight for the pilot, on the other hand, is the landing approach, especially at a busy airport or under instrument conditions.

Data compiled by the National Transportation Safety Board on civil aircraft accidents in California from 1964 to 1973 indicate that a distance of approximately one mile from the end of the runway is a reasonable limit of the area of crash probability near an airport (12). Of the 5,737 aircraft accidents that occurred during that period, 3,375 or 59% occurred on the airport property. An additional 8% occurred in the traffic pattern, and 2% occurred within a quarter of a mile. Another 3% occurred between a quarter of a mile and one mile, for a total of 72% of the accidents occurring either on the airport or within one mile of the runway. The chances of an accident occurring decrease significantly once the plane gets beyond five miles from the runway.



About 21% of all accidents happen beyond that point, but the number of accidents per mile of flight averages less than 1% per mile. It is generally agreed that it is unreasonable to try to account for these accidents in land use planning. Figure 1 is a histogram of accident frequency by distance from the airport. As can be seen from the histogram, a significant difference in accident frequency occurs at 1/4 mile from the end of the runway. This information is the basis for having two safety zones and for determining the length of the zones at the end of runways at Oakland Airport.

In determining the width of safety zones, consideration should be given to the behavior of an aircraft in trouble on take-off or landing. When an aircraft stalls or spins as the result of pilot error or mechanical failure, there is often significant horizontal departure from the original line of flight. Analysis of near airport crashes by Garbell (13) indicates that a distance of 750 feet to either side of the intended line of flight is a reasonable limit of this horizontal movement.

The recommended dimensions, then, of the airport safety zones for Oakland Airport are as follows:

Zone A (closest to runway)

Length: 1400 feet  
Width: 1500 feet

Zone B (contiguous to and beyond Zone A)

Length: 3900 feet  
Width: 1500 feet

(Note that the length of Zone A plus the length of Zone B equals 5300 feet, or 1 mile rounded to the nearest 100th foot.)

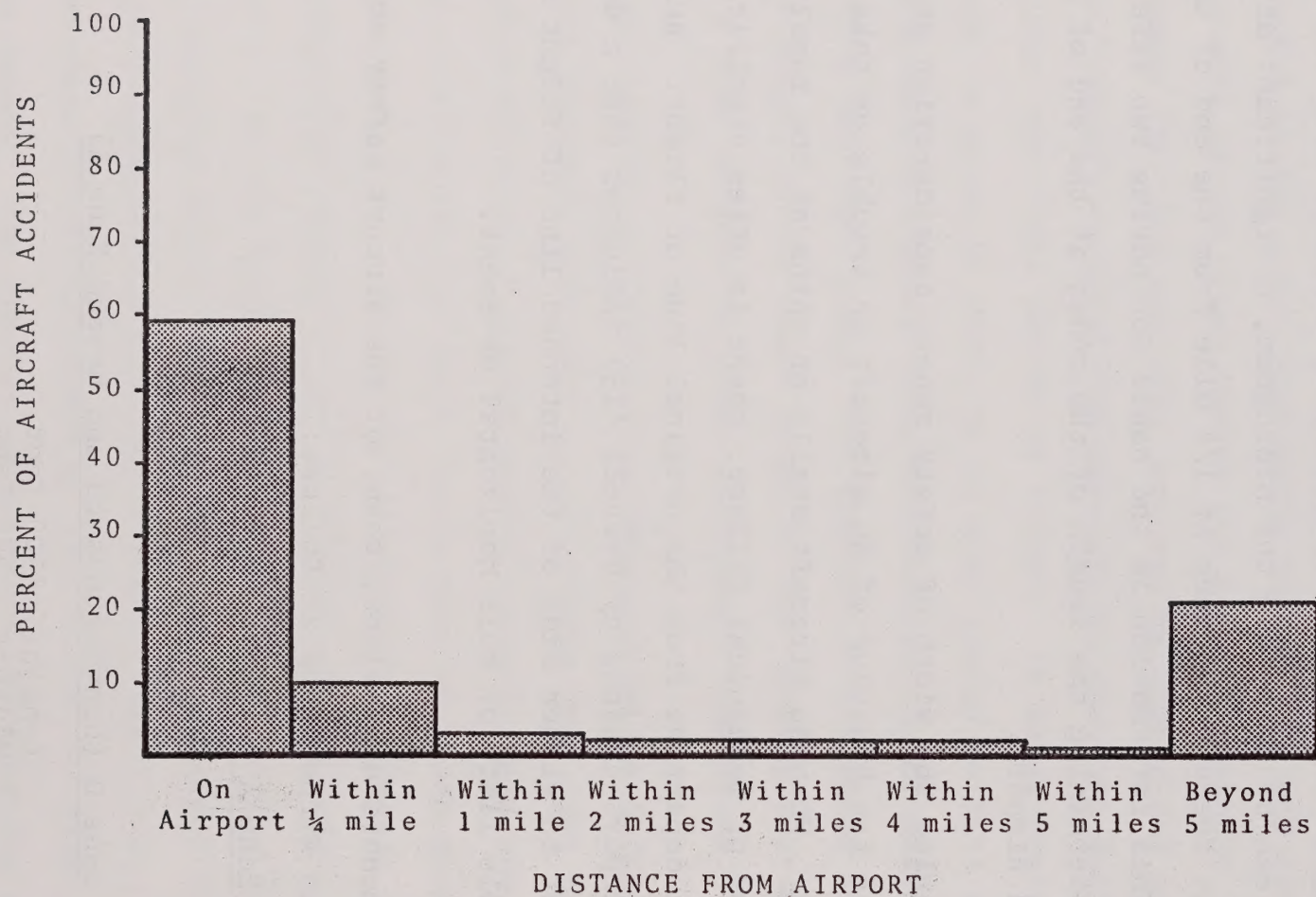


FIGURE 1. HISTOGRAM OF CALIFORNIA CIVIL AIRCRAFT ACCIDENTS, 1964-1973, BY AIRPORT PROXIMITY.

Source: National Transportation Safety Board.



Widths should be 750 feet to either side of the center line of the flight track. Where parallel runways are used, as is the case in the North Airport, the width should be 1500 feet plus the distance between the runways. These dimensions are in good agreement with other airport safety zone recommendations, notably those of the Doolittle Commission (14), the City of Inglewood (15), Santa Clara County (16), McElroy (17), and Garbell (18). For example, Santa Clara County and Garbell recommend zones with overall dimensions of 5000 feet by 1500 feet. McElroy recommends a zone with a length of 1 mile (5280 feet), and the Doolittle Report recommends a clear zone (similar to Zone A) with dimensions of 1000 feet by 1/2 mile.

#### 4. Accident Magnitude

A review of civil aircraft accidents will show that most crashes involve light general aviation aircraft and that, in the majority of cases (78%), only minor or no injuries result. In some 7% of the accidents, serious injuries occur, and in 15% of the accidents, one or more persons are killed (19). From this, it can be concluded that only relatively few air crashes are major disasters. This is particularly true with respect to persons on the ground. In 1970, 383 persons were killed in air crashes near airports, but only four of these were not occupants of the plane (20).

The magnitude or impact of an air crash varies greatly with the size, weight, and speed of the aircraft, as well as with the density of people on the ground and type of structures impacted. To give a subjective estimate of crash impacts, McElroy offers

some interesting comparisons of the impact energy of a crashing plane (21). A light personal aircraft (e.g., Cessna 150) crashing on take-off is compared to a Volkswagen sedan crashing at 54 miles per hour into a structure (a single family home, an apartment, a shopping center, etc.). An aircraft in the air taxi class (e.g., Beechcraft Air King) is compared to a ten-ton truck traveling at 61 miles per hour, and a Boeing 727 would be the equivalent of a diesel locomotive with three loaded boxcars and one tank car loaded with jet fuel traveling at 60 miles per hour.

These qualitative images give some basis for determining the impact of an air crash, but generalized quantitative measures are also possible. Air crashes pose a threat to both the life and property of people on the ground. On the premise that the first responsibility of government is to protect life, and only secondly to protect property, impacts of air crashes are dealt with here only in terms of human life.

One of the problems in applying crash data to the portion of Bay Farm Island within the safety zones is the limited number of actual crashes that have occurred in residential areas. The impact estimates used in this report are based on three crashes into residential areas in the U.S. which have occurred since 1965. The three are: (1) DC-8: Kenner, Louisiana; March 30, 1967; (2) Fairchild-Hiller FH-227B; Albany New York; March 3, 1972; and (3) Boeing 737, Chicago-Midway Airport; December 8, 1972. All three of these crashes involved damage to homes and deaths of non-occupant persons, as indicated in Table 3.



TABLE 3

## RESIDENTIAL AREA CRASH DATA

| Crash          | Aircraft Type | Gross Weight (lbs.)  | Gross Residential Density at Crash Site (dwelling units/acre) | Dwelling Units Destroyed | Dwelling Units Damaged (excluding destroyed) | <u>Non-Occupant</u> |                 | Area of Damage, Debris (Sq.Ft.) |
|----------------|---------------|----------------------|---------------------------------------------------------------|--------------------------|----------------------------------------------|---------------------|-----------------|---------------------------------|
|                |               |                      |                                                               |                          |                                              | Persons Killed      | Persons Injured |                                 |
| 1<br>(Kenner)  | DC-8          | 180,000 <sup>1</sup> | 15                                                            | 2+ Parts of Motel        | 1+ Motel                                     | 13                  | 0               | 50,000                          |
| 2<br>(Albany)  | FH-227B       | 43,343               | 5                                                             | 1                        | 0                                            | 1                   | 4               | 10,000                          |
| 3<br>(Chicago) | B-737         | 85,000               | 8                                                             | 4                        | 5                                            | 2                   | 2               | 30,000                          |

Source: City of Inglewood (22)

Quantitative estimates of crash impact may be derived from data in Table 3, using aircraft weight and population density as the governing parameters. The equation is:

$$I = KWD$$

where,

I = impact of crash, in non-occupant deaths,

K = a constant determined from historical crashes,

W = weight of aircraft in thousands of pounds, and

D = population density, in persons per acre.

K, for the three crashes listed in Table 3, is found by

$$K = \frac{I}{WD},$$

where the population density, D, is assumed to be three times the dwelling density.

$$K \text{ for the Kenner crash} = \frac{13}{180 \times 45} = .0016$$

$$K \text{ for the Albany crash} = \frac{1}{43 \times 15} = .0016$$

$$K \text{ for the Chicago crash} = \frac{2}{85 \times 24} = .0010$$

The final form of the equations used in this report, then, is

$$I = .0015 (W)(D)$$

The FAA operations data for the first quarter of 1976 indicate that the types of aircraft using the straight-out take-off pattern ranged from twin-engine general aviation aircraft to Boeing 737's prior to the Port's ban of jets. Table 4 provides a summary of the range of aircraft using the straight-out pattern their maxi-



TABLE 4

ESTIMATED IMPACTS OF AIR CRASHES  
ON BAY FARM ISLAND

| AIRCRAFT<br>TYPE           | MAXIMUM GROSS <sup>1</sup><br>WEIGHT, LBS. | CRASH IMPACT,<br>NON-OCCUPANT<br>DEATHS |
|----------------------------|--------------------------------------------|-----------------------------------------|
| Cessna 320C<br>Skynight    | 5,200                                      | 0.20                                    |
| Lear Jet<br>Model 23       | 12,500                                     | 0.49                                    |
| Aero Jet<br>Commander 1121 | 16,000                                     | 0.62                                    |
| Boeing 727                 | 142,000                                    | 5.53                                    |
| Vickers VC10               | 312,000                                    | 11.7                                    |
| Douglas DC-8F              | 328,000                                    | 12.7                                    |

<sup>1</sup>Maximum gross weight estimates taken from Greene, The Observer's Book of Aircraft.

mum weights, and the estimated impact of a crash into the existing residential area on Bay Farm Island. Population density of the residential area was estimated from City of Alameda Planning Department data to be 26 persons per acre (24). To illustrate the use of the above equation, consider the case of a Boeing 727 crash. Since a 727's maximum gross weight is 142,000 lbs, the equation would be:

$$\begin{aligned} I &= (.0015) (142) (26) \\ &= 5.53 \end{aligned}$$

This means that 5 or 6 non-occupants of the 727 can expect to be killed in the event of its crash into existing residences on Bay Farm Island.

As would be expected, Table 4 shows there is a large difference between the impact of a B727 and Cessna twin-engine aircraft or light business jet. The value of the quantitative estimates is that they suggest levels of acceptable risk. The policy recommendations contained in Part III of this report are predicated upon an acceptable risk level at which no non-occupant deaths occur in the event of a crash. Table 4 indicates that this level is exceeded if aircraft heavier than 25,000 pounds fly over the existing residential area. The 25,000 lbs, weight limit is predicated upon non-occupant deaths equal to 0.99 as defined by the term "I" in the equation. A more conservative weight limit, and one that is consistent with FAA Aircraft weight categories, is 12,500 lbs. This weight of aircraft is associated with an impact of 0.49 non-occupant deaths in the event of a crash, and is part of the basis of the recommended level of acceptable risk. The level of 0.49 non-occupant deaths is



recommended over a level of 0.99 non-occupant deaths because at the 0.99 level the odds are that someone will still be killed. At a level of 0.49 non-occupant deaths, the odds are greater that no one will be killed than that one non-occupant person will be killed.

These quantitative estimates of crash impact also suggest approximate densities of development which are compatible with different types of aircraft. Acceptable densities can be estimated by setting  $I = 0.49$  (odds in favor of no non-occupant deaths) and solving the equation for "D." For example, if B727's fly over an area, an acceptable density would be about two to three persons per acre, assuming the acceptable risk level is based on the odds being in favor of non-occupancy deaths.

As is the case with the other criteria used in making risk decisions, these estimates of crash magnitude should not be interpreted as precise measures. Rather, they should be treated as guidelines which, together with the other criteria, form a basis for decision-making.

#### D. ALAMEDA NAVAL AIR STATION

##### 1. Operations

Alameda Naval Air Station (NGZ), also known as Nimitz Field, is located on the western end of Alameda Island, and serves as a home port for aircraft carriers. NAS Alameda's mission is to provide logistic support to units of the Pacific Fleet and other activities as designated by the Chief of Naval Operations. It serves over 29 tenant commands, including the Alameda Naval Air

Rework Facility, its largest tenant, and the Naval Air Reserve Unit, its largest military tenant.

NAS Alameda is homeport to two Carrier Air Group Staffs, 11 ships, and 9 aircraft squadrons. Only one of these squadrons, VR-30, is a unit of the active Fleet. The remaining eight squadrons are components of the Reserve Forces. NGZ also serves as a stopover point for other military aircraft. These transient stopovers account for about 30% of the airport's operations (25).

The airfield consists of two airstrips (four runways) which bisect each other. The preferential strip, R31-13, is 8,000 feet long, and the secondary strip, R-25-7, is 7,200 feet in length. Table 5 provides a summary of annual operations at NGZ, broken down by runway utilization and aircraft type.

Aircraft types are designated A, F, C, T, H, P, S, U and O, to delineate Attack, Fighter, Cargo, Trainer, Helicopter, Patrol, Search, Utility, and Observation types of planes. As is indicated in Table 5, R31 handles about 59% of all traffic, and R25 is used for about 30% of the total operations.

In terms of airport safety, the operations of concern to the City of Alameda are landings on R25. All approach and departure patterns for R31 and R13 are over water, and do not create significant safety hazards for the residents of Alameda. Use of R7 is currently limited to emergency landings. Take-offs are not permitted on this runway.



TABLE 5

SUMMARY OF ANNUAL OPERATIONS,  
ALAMEDA NAVAL AIR STATION  
March 1973 - February 1974 <sup>1</sup>

| AIRCRAFT<br>TYPE | R7      | R25   | R13   | R31    | TOTALS |
|------------------|---------|-------|-------|--------|--------|
| A-3              | 92      | 5857  | 1789  | 11,113 | 18,851 |
| A-4              | 47      | 3182  | 1007  | 6,273  | 10,509 |
| A-7              | 66      | 4040  | 1226  | 7665   | 12,997 |
| C-1              | 62      | 3759  | 1142  | 7110   | 12,073 |
| C-118            | 22      | 1398  | 427   | 2657   | 4,504  |
| C-131            | 18      | 1183  | 365   | 2260   | 3,826  |
| P-3              | 11      | 938   | 282   | 1795   | 3,036  |
| S-2              | 26      | 1887  | 580   | 3584   | 6,077  |
| H-1              | 7       | 766   | 234   | 1460   | 2,467  |
| H-3              | 44      | 2792  | 858   | 5314   | 9,008  |
| H-53             | 26      | 1675  | 518   | 3186   | 5,405  |
| G.A.             | 44      | 2861  | 883   | 5445   | 9,233  |
| Others           | 69      | 4566  | 1409  | 8705   | 14,749 |
| Subtotals:       | 534     | 34904 | 10730 | 66567  |        |
| Total:           | 112,735 |       |       |        |        |

<sup>1</sup> NAS Alameda aircraft operations are reducing at an annual rate of 10% through 1976.

Source: Robin M. Towne and Associates (26).

Use of Runway 25 is limited primarily to the months of May, June, July, and August, when strong westerly winds commonly blow through the Golden Gate (27). There are two approach patterns used by aircraft landing on R25. The normal pattern is a straight-in approach over the Oakland hills east of NGZ and then over a set of cranes located about 3/4 of a mile from the end of the runway approach end. A second approach, which is reserved for high performance and carrier aircraft only, is the 360° Overhead Break pattern. Pilots using the Overhead Break fly a course that takes them directly over R25 at an altitude of 1900 feet. Over the upwind end of the runway, they begin a descending left-hand turn which takes them back around to an imaginary point one-half mile south of Ballena Bay, called Point Alpha. Here the aircraft should be at 1500 feet. The pilot then executes another left-hand turn onto the base leg of the approach which is flown directly over Webster Street in Alameda. Over the estuary on the north side of the island, the pilot makes another left-hand turn and is on final approach over the Todd Shipyard cranes (28).

Use of this approach pattern is limited primarily to A-3, A-4, and A-7 type aircraft, and is only used infrequently for reasons of noise abatement. Operations data indicate that the Overhead Break is used about 810 times annually, which comprises 2.3% of the use of Runway 25 (29).



## 2. Accident Potential Zoning

The methodology for evaluating risk levels due to operations at military air fields, which has been developed by the Department of Defense, is called the Accident Potential Zone (APZ) Program. The Navy APZ Program guidelines of August 19, 1975 (as amended January, 1976) were used by Navy staff to delineate the appropriate Accident Potential Zones for NAS Alameda (30). These zone delineations are shown on the Airport Safety Zones Map (rear map pocket) and are incorporated into this General Plan Safety Element for purposes of airport safety planning in the City of Alameda near NAS Alameda.

The basic Department of Defense APZ guidelines (April 10, 1975) read, in part, as follows:

### "General

A. Department of Defense Instruction 4165.57, "Air Installations Compatible Use Zones" requires that the Secretaries of the Military Departments "Determine...areas of high potential...." in developing AICUZ programs for each installation.

B. Studies have indicated that the areas immediately beyond the ends of runways experience more aircraft accidents than the country in general or even than other areas of intense flying activity. For this reason, these areas should not be subjected to high density development but should remain sparsely developed, if at all, in order to limit, as much as possible, the adverse effects of an aircraft accident should one occur.

C. The extent of the areas having high accident potential is dependent on the type of aircraft being flown from a particular runway. That is, light, small, generally slower aircraft tend to have accidents in a narrower and shorter area beyond a runway than do heavy, high speed or large aircraft. That this should be so is intuitively obvious but has been confirmed by analysis.

D. Accordingly, DOD runways are separated into two types for the purpose of defining accident potential areas. Type A runways are those restricted to small light aircraft and which do not have the potential for development to heavy aircraft use or for which no foreseeable requirement for such use exists. Typically these runways are restricted to Army installations,



have less than 10% of their operations involving aircraft in Class B, and are less than 8,000 feet long. Class B runways are all other runways.

E. It is emphasized that the following are guidelines only. Their strict application would result in increasing the safety of the general public but would not provide complete protection against aircraft accidents. Such a degree of protection is probably impossible to attain. Local situations may differ significantly from the assumptions upon which these guidelines are based and require individual study. Where it is desirable to restrict the density of development of an area, it is not usually possible to state that one density is safe and another is not. Safety is a relative term and our objective should be the realization of the greatest degree of safety that can reasonably be attained."

It is important to note that the APZ guidelines were developed specifically for application to military air operations, and should not be considered applicable to civil operations without extrapolation. Military aircraft, especially attack and fighter aircraft, perform differently than private or commercial civil aircraft. Accordingly, the accident potential zones are different for military airports. It is also important to note that the APZ guidelines are still in the early stages of development and are subject to change. Additionally, the APZ study of NAS Alameda conducted by Navy staff for this report is preliminary and did not go to the level of detail of a fully funded analysis. However, the APZ guidelines used in evaluating accident potential at NAS Alameda are the most recent, and they are currently being used on a nationwide basis. As the guidelines are updated, or when a more detailed analysis is conducted, this report should be reviewed and revised if necessary.



The first step in determining the APZs for NAS Alameda was to draw the standard APZ as described in the Department of the Navy Draft APZ Guidelines. Essentially, these guidelines call for the establishment of the following zones near NAS Alameda:

1. A Clear Zone 3,000 feet long (from the end of the runway), 2,300 feet wide at the end farthest from the runway (1,150 feet on either side of the runway center line), and 1,500 feet wide at the end nearest to the runway (750 feet on either side of the runway center line). The resulting fan-shaped Clear Zone is based on the standard approach fan as defined in Federal Aviation Regulations, Part 77.
2. Accident Potential Zone I, which is the area beyond the Clear Zone within a length of 5,000 feet and a width of 3,000 feet.
3. Accident Potential Zone II, which is the area beyond APZ I having a measurable potential for accidents. For the type of aircraft in use at NGZ, this zone is 7,000 feet long and 3,000 feet wide.

After establishing these basic Accident Potential Zones, a number of elements were analyzed by Navy staff to determine whether zone modifications were appropriate. These elements include the number of operations in each flight pattern, the ten-year accident history at NGZ, specific operational conditions on Runway 25, and objects affecting navigable air space. As a result of these evaluations, the APZ's shown on

the Airport Safety Zones Map (rear map pocket) were developed. The only major modification of the basic APZ's at NAS Alameda is the absence of an APZ I or II for the Overhead Break pattern along Webster Street. The Navy Guidelines state that infrequent runway use (less than 5,000 annual operations) is cause for deletion of APZ's I and II from a flight pattern. Since the Overhead Break on Runway 25 is used by fewer than 1,000 aircraft annually, APZ's I and II were not extended along Webster Street.

A review of the accident history did not support expansion or reduction of the standard APZ dimensions and served primarily to underscore the importance of the Clear Zone. The majority of recorded mishaps resulted from malfunctions occurring while the aircraft was on the runway (31).

Analysis of operating conditions on Runway 25 and objects affecting navigable air space (in accordance with FAA Regulations, Part 77) revealed two things. First, wind conditions during summer afternoons often necessitate exclusive use of Runway 25, even for called-in emergency landings. Secondly, the two cranes located at the Todd Shipyard were found to project 116 feet into the approach-departure clearance surface. These cranes are located in APZ I. These conditions resulted in the retention of the standard APZ's I and II on the approach pattern to Runway 25.



The level of acceptable risk within these APZ's is defined by the recommended land use policies for each of the Zones. These policies are listed in Section IIID.

#### E. CONCLUSIONS

1. The issue of airport safety is important to the City of Alameda because of the proximity of populated areas of the community to runways at Oakland Airport and Alameda Naval Air Station.

2. Analysis of air operations and existing land use within the City indicates there are two hazardous areas in the City with respect to potential aircraft accidents. These are:

(a) the residential development located on Bay Farm Island under the flight path of aircraft using a straight-out departure pattern from Runways 27R and 27L, and (b) a strip of commercial and industrial development along the north edge of Alameda Island located under the straight-in approach route of Navy aircraft landing on Runway 25.

3. Evaluation of three risk criteria - accident frequency, location, and magnitude - for operations at Oakland Airport yields the following:

(a) On the average, Oakland Airport as a whole can expect one accident associated with its approach and departure operations to occur about every two years, assuming that the existing level of operations is continued. The North Airport complex alone can expect one accident to occur about every

three years. Straight-out take-off operations from Runways 27R and 27L can expect, on the average, to be the source of an aircraft accident about every 105 years.

(b) The most probable location of an aircraft accident is the airport property itself. Most of the near-airport accidents at OAK can be expected to occur within one mile of the end of the runway, with the preponderance of those accidents occurring within 1/4 mile of the runway.

(c) The magnitude of potential air crashes in Alameda will vary with the weight of the aircraft and the population density at the crash site. Estimates of crash impact of existing Bay Farm residential development, in terms of non-occupant deaths, range from none in the event of a light, general aviation aircraft crash to 13 in the event of a large, air carrier aircraft crash. Jets and heavy aircraft have recently been banned from straight-out flight patterns on Runways 27R and 27L, however, significantly reducing the upper limit of the range of crash impact.

4. Evaluation of aircraft accident potential at Alameda Naval Air Station was conducted in accordance with Department of the Navy Draft Guidelines for Accident Potential Zones determination. In this program, acceptable risks are defined by land use policies for the Accident Potential Zones. These policies are listed in Section IIID.



### III. POLICY RECOMMENDATIONS

#### A. CONTEXT

The technical information presented in the preceding section of this report is generalized to a certain extent, and is subject to change with time, but can be used by persons engaged in the planning process in the City of Alameda. The basic purpose of these technical analyses is to provide the necessary criteria for determining the level of risk from aircraft accidents which is acceptable to the community. This determination is ultimately the responsibility of public decision-making bodies. It is also a public responsibility of the community to determine what action, if any, is necessary to reduce risks or mitigate their impact, should they be realized. As a part of the General Plan Safety Element, this report is intended to serve as a tool in making these determinations.

It is in this context that the policy recommendations of this section are made. These recommendations assume a given level of acceptable risk which may or may not be the same level of risk considered acceptable by the community of Alameda. It is possible, therefore, that the recommended policies will be changed in accordance with different perceptions of risk. It is also possible that the policies will change with time. As part of the General Plan, these policies are intended to assist decision-makers for some twenty years. The risk factors upon which the recommended policies are based may well change in that period of time, but it is assumed that the Alameda Naval Air Station will maintain approximately the same level of operations for the foreseeable future; and the Oakland International will probably grow.



Thus, the following policies are primarily a short-term plan, but are also long-term guidelines which should be amended as dictated by basic changes in airport operations.

## B. GOALS

The basic goals of the Safety Element which guided the preparation of specific policies are outlined below:

1. To minimize loss of life and injuries which result from air crashes in Alameda affecting ground populations.
2. To minimize loss of property and secondary social and economic dislocations which result from air crashes.
3. To provide for effective emergency response in the event of a crash and the early restoration of a normal level of activity.

These goals are a statement of the basic purposes of this part of the Safety Element, and are a necessary component of consistent planning. They are the guidelines which can be held up against specific policies or proposals to determine the effect of those proposals on public safety.

## C. OAKLAND AIRPORT SAFETY POLICIES

### 1. General

Airport safety is a function of both airport operations and land use planning. These two aspects of the safety issue are closely related and cannot be considered realistically as separate questions. A change in the number or type of operations affects the type and density of land use that is considered acceptable, and vice versa. Thus, in this section



the land use policies for the airport safety zones are considered to be governed by the operations at Oakland Airport. If the level or type of operations changes, so do the planning policies for Bay Farm Island. Three alternative operational settings are considered. The first setting is a continuation of existing operations. As described in the Technical Analysis, straight-out patterns from Runways 27L and 27R are limited under existing conditions to IFR operations of single and twin-engine reciprocating engine aircraft and turboprop aircraft weighing less than 12,500 lbs. For purposes of determining land use policy, it is assumed that there are no violations of the Port's policy banning jets, heavy turboprop aircraft, and 4-engine reciprocating engine aircraft. It is also assumed that there are no violations of the Port's policy requiring a turn over the golf course by aircraft departing under VFR conditions. Given these assumptions, the greatest risk to existing residential areas is posed by overflights of single or twin reciprocating engine aircraft that weigh more than 12,500 lbs. (assuming that the acceptable risk level is defined as having the odds in favor of no non-occupant deaths). There are very few, if any, single reciprocating engine aircraft that weigh that much, and no such aircraft are shown in the records of the operations for Runway 27 IFR departures. However, there are a few twin-reciprocating engine aircraft that weigh more than 12,500 lbs., and a small percentage (less than 1%) of the IFR departures from Runways 27L and 27R is composed of them. The most common of these heavy twin-engine aircraft is the McDonnell-Douglas DC-3, an older transfer type plane which weighs between 25,000 and 30,000 lbs.



The recommended population density of Alternative One is based on a crash of this type aircraft as a worst case.

The second alternative policy setting assumes an expansion of the Port's recent ban to include all aircraft weighing more than 12,500 lbs. This has the effect primarily of eliminating the worst case crashes that are possible under existing conditions, and so changes the recommended population density within the airport safety zones. The prohibition of heavy aircraft could be enforced, in part, by foreshortening the runway by paint (if not physically).

The third alternative policy setting assumes that (1) as in Alternative Two, all aircraft weighing more than 12,500 lbs. are prohibited from straight-out departures or straight-in landings over Bay Farm Island, and that (2) straight-out IFR departures from Runways 27R and 27L are prohibited from making intersection take-offs. An intersection take-off is one which begins at the intersection of a taxiway with the runway rather than at the end of the runway. Under existing conditions, almost all IFR departures are non-intersection take-offs, that is, the start of the take-off roll begins at the end of the runway. FAA tower personnel estimate that the number of IFR aircraft using intersection take-offs is negligible (less than 1%). VFR departures from Runway 27 using intersection take-offs are estimated to comprise about 5% of the total VFR departures. The safety advantage associated with non-intersection take-offs, with respect to Bay Farm Island residents, is that the closer an aircraft begins its take-off roll to the end of the runway, the higher and more stable it will be when passing over the residences near the end of the run-



way. The chances of an aircraft coming down within the existing development are thereby decreased somewhat.

## 2. Alternative One: Existing Conditions

If existing use of Runways 27R and 27L by large piston-powered aircraft is continued, the following risk criteria may be considered to apply:

Accident frequency: approximately once per 105 years (substantially less frequently for large "worst case" accident).

Accident location: most probably within 1/4 mile of the end of the runway; second most likely location is between 1/4 and one mile from the end of the runway; lateral variance is 750 feet to either side of the flight track centerline.

Accident magnitude: range of estimates varies from the odds favoring no non-occupant deaths for aircraft under 12,500 lbs. to about 13 non-occupant deaths for large commercial jets (based on existing Bay Farm Island residential densities). The worst case accidents under the existing ban of jets is estimated to result in one to two non-occupant deaths.

Assuming the level of acceptable risk is defined by the 105 year worst case accident and no non-occupant deaths, the appropriate policies for Airport Safety Zones A and B (see Airport Safety Zones Map) are:

### Zone A

1. No structure or object should be erected or permitted to grow above the primary surface of the runway, with the exception of structures to aid navigation.
2. Land should be graded and turfed.

## Zone B

1. Land use should be non-residential and restricted to the following uses:
  - (a) agriculture
  - (b) recreation/parks
  - (c) equipment storage/corporation yards
  - (d) single story automobile parking
  - (e) single story, limited-occupancy warehousing
  - (f) single story, limited-occupancy municipal activities (e.g., sewage treatment plants)
2. For any particular land use average annual population density should be no greater than 10 persons per acre.

These policies would have the effect of yielding part of the existing residential development on Bay Farm Island on incompatible land use. It should be remembered, though, that the number of heavy twin-engine aircraft which would probably result in non-occupant deaths in the event of a crash into Bay Farm Island residences is very small. Relocating persons living in the exposed residences now, in response to the potential for such an accident, would be very costly and is most probably impractical. However, future development within Zone B should be planned to conform with the density recommended in Policy 2.

### 3. Alternative Two: Prohibition of All Aircraft Weighing More Than 12,500 lbs.

The policies of this section are predicated on the prohibition of all aircraft weighing more than 12,500 pounds from using a straight-out take-off from Runways 27R and 27L or a landing on Runways 9L and 9R. Aircraft weighing less than 12,500 pounds would still be permitted to use the straight-out IFR pattern.



This has the effect of altering the applicable risk criteria, and represents the best long-term solution to airport related safety hazards. The most effective solution, of course, would be the prohibition of all flights using the straight-out pattern. However, according to the estimates of crash magnitude developed in Section II, an acceptable level of risk (odds favoring no non-occupant deaths) can be attained for the existing population density by prohibition of aircraft weighing more than 12,500 pounds.

Applicable risk criteria in this alternative are as follows:

Accident Frequency: approximately once per 105 years.

Accident location: most probably within 1/4 mile of the end of the runway; second most likely location is between 1/4 and one mile from the end of the runway; lateral variance is 750 feet to either side of the flight track center line.

Accident magnitude: estimates indicate that no non-occupant deaths should occur based on existing population density.

Assuming that these criteria define the level of acceptable risk, the appropriate policies for Airport Safety Zones A and B are:

#### Zone A

1. No structure or object should be erected or permitted to grow above the primary surface of the runway with the exception of structures to aid navigation.

#### Zone B

1. Residential land use should be discouraged. However, if there are no other feasible locations for residential development and population densities do not exceed the density prescribed in Policy 3, residences may be located in Zone B.



2. Land use should preferably be limited to the following:
  - (a) agriculture
  - (b) recreation/parks
  - (c) equipment storage/corporation yards
  - (d) single-story automobile parking
  - (e) single-story warehousing
  - (f) single-story municipal activities
3. Average annual population density should be no greater than 25 persons per acre.

According to these policies, existing land use and density on Bay Farm Island is acceptable. Future development within Zone B should not exceed existing population densities, however, and residential use should be discouraged.

4. Alternative Three: Prohibition of Intersection Take-Offs

This alternative policy setting is predicated on Alternative Two, the prohibition of aircraft weighing more than 12,500 lbs. being realized, and on the prohibition of IFR intersection take-offs. The applicable risk criteria in this setting are the same as those for Alternative Two. The principal difference between these alternatives is that non-intersection take-offs result in a somewhat safer flight over Bay Farm Island residential development, which affects the recommended land use policies.

Starting the take-off roll at the end of the runway should not affect the size or location of the proposed safety zones for two reasons. First, the zones are based on accident data which is not dependent on the location of the start of the take-off roll. Secondly, as long as the physical runway is present, there is the opportunity for a pilot to use it. Although this would most probably occur only under unusual conditions, the fact that it can happen lends support to the location of the zones at the end of the runway rather than on the runway.



The impact of prohibiting intersection take-offs is to make somewhat higher population densities and residential use within Zone B acceptable. The policies for this alternative, then, are the same as those of Alternative Two with the exceptions that residences need not be discouraged in Zone B and the average annual population density should not exceed 30 persons per acre (as compared to 25 persons per acre under Alternative Two).

Evaluation of the above three alternatives leads to the conclusion that the most desirable operational setting, in terms of safety for Bay Farm Island residents, is Alternative Three. Therefore, the City should take what steps it can to work with the Port of Oakland in developing the appropriate operating policies. If the conditions of Alternative Three are not met, the City should implement the policies of Alternative One to deal with existing conditions, or the policies of Alternative Two if aircraft weighing more than 12,500 lbs. are prohibited. It should be noted that the Port's existing policy which bans jets, heavy turboprop aircraft, and four engine reciprocating-engine aircraft from Runways 27R and 27L has already substantially reduced the risk of a high magnitude aircraft accident on Bay Farm Island. The operating conditions of Alternative Two and Three represent relatively small expansions of existing Port policy.

As a final note on land use policies relative to OAK, Safety Zones A and B are depicted on the Airport Safety Zones Map for the runways other than Runways 27R and 27L. In only one instance do any of these zones impinge on a populated area of the City. The edge of Zone B for Runway 33 falls on the southeastern tip of Alameda



Island in a low density residential area. The population density of this area is about the same as that on Bay Farm Island (26 people/acre), and Runway 33 is used only by light, general aviation aircraft. This situation is comparable to that described in Alternative Two for the Runway 27 complex, and the same policies recommended for Bay Farm Island should be implemented here. That is, future development or redevelopment in that area should not exceed an average density of 25 persons per acre.

The safety zones for the other runways at OAK lie over either bay water or land outside the City of Alameda, so specific policies for them have not been developed as a part of this report.

Safety zones for Runway 15 are not delineated because of its infrequency use and the fact that the Port of Oakland foreshortened the runway (by paint, not physically) thereby providing a safety area on airport property.

#### D. NAS ALAMEDA SAFETY POLICIES

Relatively little privately-owned land in the City of Alameda is located within the Accident Potential Zones delineated around Alameda Naval Air Station. Most of the land within the Clear Zone, APZ I, and APZ II is either U.S. Navy property or is located in the City of Oakland. There is no private property in Alameda located in the Clear Zone, and only portions of two parcels owned by a single individual are located in APZ I. Private property in APZ II comprises portions of parcels under three separate ownerships.

Land use policies for private property in Alameda within APZ I and APZ II were developed by City staff in conjunction with planning and safety staff at NAS Alameda and the Naval Facilities



Engineering Command, Western Division, in San Bruno. The basic objective of the policies is to restrict large gatherings of people in highly concentrated groupings of buildings. These policies also recognize that the property within the Accident Potential Zones is bordered by the Estuary which has an open surface area greater than the area of the private property. The recommended land use policies for Accident Potential Zones I and II are as follows:

#### APZ I

1. Seventy-five percent of the total land within the area of APZ I under City jurisdiction should be maintained as open space. For purposes of computing open space requirements, parking lots should not be considered open space, but public roadways may be. The General Plan Land Use Element should designate those areas to be maintained as open space.
2. Residential land use should be prohibited.
3. Non-residential land uses should be permitted, but the density of development should be regulated to prohibit gatherings of large numbers of people in a single building (e.g., restaurants, clubs). Small, recreation-oriented commercial shops should be encouraged as the major land use. Occupation of any single building should be limited to 150 persons.
4. Height restrictions should be established limiting buildings to two stories.

#### APZ II

1. Fifty percent of the total land within the area of APZ II under City jurisdiction, should be maintained as open space. For purposes of computing open space requirements, parking lots should not be considered open space, but public roadways may be. The General Plan Land Use Element should designate those areas to be maintained as open space.
2. No additional residential uses or development should be permitted.
3. Occupation of any single building should be limited to 200 persons.
4. Height restrictions should be established limiting buildings to three stories.



In reviewing the above policies, several things should be noted. First, it is recommended that parking lots not be designated as open space since they are access features of developments in this area of the City. To allow parking lots to be included in open space calculations would encourage larger buildings and a greater intensity of development than is the intent of these safety policies. The basic thrust of the safety policies is to limit large concentrations of people in single structures, and not designating parking lots as open space is a flexible way to help assure reasonable limits to building size and occupancy on a parcel-by-parcel basis.

Residential use is prohibited in the Accident Potential Zones, with the exception of existing houseboats in APZ II. Population densities are usually higher in residential areas on the average and typical frame construction is not resistant to high impact crashes associated with military aircraft. Thus, residences are normally susceptible to higher casualty risks than other land uses. The houseboats are exempt from the prohibition primarily because they are an existing use and the cost of relocating them would be prohibitive. However, no expansion or increase in density at the marina should be allowed.

As a final note, the cranes at Todd shipyard which protrude into the approach pattern for Runway 25 at NAS Alameda are not banned by the above policies. They were present before NAS Alameda was developed and they occupy a legal position under a "grandfather clause." The Navy has modified the approach pattern to Runway 25 to minimize the potential hazard created by the cranes. Rather than approach on a glide path of 2.0 to 3.0 degrees, aircraft



landing on Runway 25 approach at a steeper angle of 3.5 degrees in accordance with the military waiver granted to NAS Alameda. In addition, the decision to continue or abort an approach is made farther from the airport and at a higher altitude than at fields where no obstruction occurs. This prevents a pilot from continuing his approach unless he has the runway in sight and can continue his descent to avoid the cranes.

#### E. EMERGENCY RESPONSE

One of the important functions of the Seismic Safety and Safety Elements is to provide estimates of hazardous events for use in emergency response planning. The data contained in the report should be reviewed by those in Alameda with authority for accident response to determine their ability to respond to aircraft accidents. It is recommended that aircraft accident profiles or scenarios be developed for a range of potential accidents including the maximum probable accident. These profiles should include estimates of occupant casualties and total property damage, and should be used to develop standards for accident response capability.





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# GENERAL PLAN

- RESIDENTIAL**
- 1-5 DWELLING UNITS / NET ACRE
  - 6-10 DWELLING UNITS / NET ACRE
  - 11-15 DWELLING UNITS / NET ACRE
  - 16-20 DWELLING UNITS / NET ACRE
  - 21-30 DWELLING UNITS / NET ACRE
  - 31-40 DWELLING UNITS / NET ACRE

- COMMERCIAL**
- GENERAL
  - T TOURIST COMMERCIAL
  - A AUTOMOBILE & RELATED
  - SC SHOPPING CENTER
  - N NEIGHBORHOOD COMMERCIAL

- INDUSTRIAL**
- LIGHT
  - MEDIUM
  - TIDELANDS

**PUBLIC & QUASI-PUBLIC**

- G GOVERNMENT
  - S SCHOOL
  - F FIRE STATION
  - U UTILITY
  - M MEDICAL & RELATED
  - H HISTORICAL AREA
  - MILITARY
  - PARK
  - OPEN SPACE
- ◆ SITE TO BE SELECTED

**CIRCULATION & TRANSPORTATION**

- FREEWAY
  - ARTERIAL STREET
  - COLLECTOR STREET
  - RAPID TRANSIT STATION WITH PARKING
  - RAPID TRANSIT ROUTE
  - RAPID TRANSIT INTER-MODAL TERMINAL
  - ★ GENERAL PLAN AMENDMENT - CONTACT PLANNING DEPARTMENT FOR DETAILS
- THREE ALTERNATIVES SHOWN

It is intended that areas designated for 1-5 and 6-10 dwelling units per net acre be limited to single family development of one unit per lot; however, where zoning allows, all lots that are not subdividable into standard size lots and all lots where subdivision would result in lots with a depth of more than three times the frontage, which lots contain from 10,000 to 15,000 square feet, may have two dwelling units per lot, and which lots contain above 15,000 square feet, may have the number of units proportional to a density of 10 dwelling units/acre.

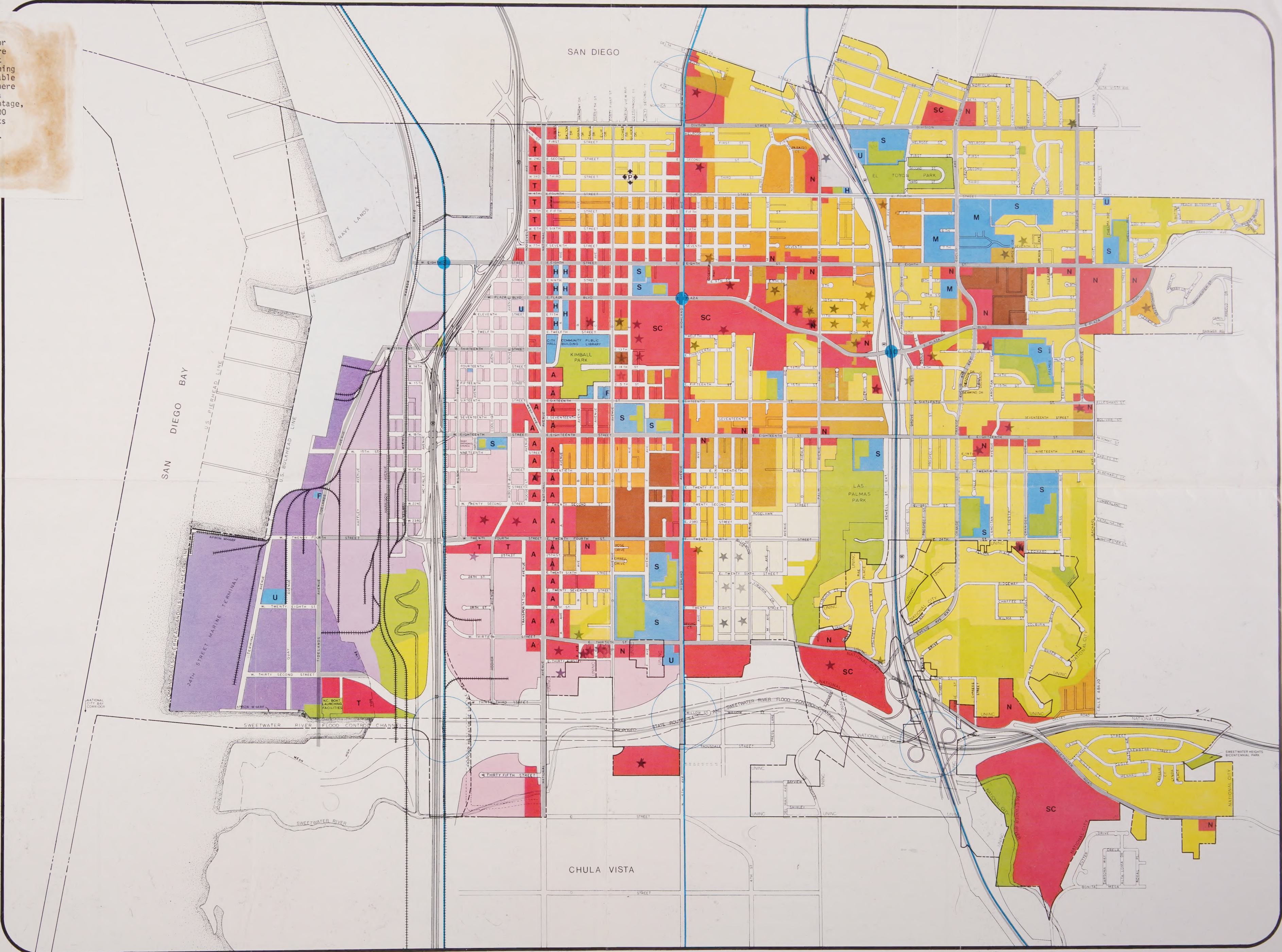
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GENERAL PLAN  
REVISION  
PROGRAM  
1973-74

**DUNCAN & JONES**  
Urban & Environmental Planning Consultants





COMPATIBILITY MATRIX

GENERAL PLAN DESIGNATIONS

ZONE'S

|               | Residential                        |                                     |                   |                   |                   |                   |                 |                                    | Commercial |       |                    |                      |                 | Industrial              |       |        |       | Public & Quasi-Public |            |        |              |         |                   |                 |          |      |            |
|---------------|------------------------------------|-------------------------------------|-------------------|-------------------|-------------------|-------------------|-----------------|------------------------------------|------------|-------|--------------------|----------------------|-----------------|-------------------------|-------|--------|-------|-----------------------|------------|--------|--------------|---------|-------------------|-----------------|----------|------|------------|
|               | 1-5 DU/Net Acre (One Unit Per Lot) | 6-10 DU/Net Acre (One Unit Per Lot) | 11-15 DU/Net Acre | 16-20 DU/Net Acre | 21-30 DU/Net Acre | 31-40 DU/Net Acre | 40+ DU/Net Acre | Senior Housing/Density Unspecified | General    | Heavy | Tourist Commercial | Automobile & Related | Shopping Center | Neighborhood Commercial | Light | Medium | Heavy | Tidelands             | Government | School | Fire Station | Utility | Medical & Related | Historical Area | Military | Park | Open Space |
| RS-1          | X                                  |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RS-2          | X                                  | X                                   |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RT            | X                                  | X                                   | X                 |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RM-1          | X                                  | X                                   | X                 | X                 | X                 | X                 |                 | X                                  |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RM-2          |                                    |                                     |                   |                   |                   |                   | X               | X                                  |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RM-3          |                                    |                                     |                   |                   |                   |                   | X               | X                                  |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| RMH           |                                    | X                                   | X                 | X                 |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            |         |                   | X               | X        | X    | X          |
| IC            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| IP            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| CT            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       | X                  |                      |                 |                         |       |        |       |                       |            | X      | X            |         | X                 | X               | X        | X    | X          |
| CA            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    | X                    |                 |                         |       |        |       |                       |            | X      |              |         |                   | X               | X        | X    | X          |
| CL            |                                    |                                     |                   |                   |                   |                   |                 |                                    | X          |       |                    |                      |                 | X                       |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| CG            |                                    |                                     |                   |                   |                   |                   |                 |                                    | X          |       |                    |                      |                 |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| CH            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            | X     |                    |                      |                 |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| CBD           |                                    |                                     |                   |                   |                   |                   |                 | R                                  | X          |       |                    |                      | X               |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| CSC           |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      | X               |                         |       |        |       |                       |            | X      | X            | X       | X                 | X               | X        | X    | X          |
| ML            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         | X     |        |       |                       |            | X      | X            | X       |                   | X               | X        | X    | X          |
| MM            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       | X      |       |                       |            | X      | X            | X       |                   | X               | X        | X    | X          |
| MH            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        | X     |                       |            | X      | X            | X       |                   | X               | X        | X    | X          |
| MT            |                                    |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       | X                     |            | X      | X            | X       |                   | X               | X        | X    | X          |
| DS Limit      | X                                  |                                     |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D10           |                                    | X                                   |                   |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D15           |                                    |                                     | X                 |                   |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D20           |                                    |                                     |                   | X                 |                   |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D30           |                                    |                                     |                   |                   | X                 |                   |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D40           |                                    |                                     |                   |                   |                   | X                 |                 |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D40+          |                                    |                                     |                   |                   |                   |                   | X               |                                    |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |
| D Unspecified |                                    |                                     |                   |                   |                   |                   |                 | X                                  |            |       |                    |                      |                 |                         |       |        |       |                       |            |        |              |         |                   |                 |          |      |            |

- ☒ Those zones that are compatible with the Land Use Category.
- ☒ Those zones that are compatible only when a Redevelopment Plan adopted by the City Council applies thereto.
- ☐ Those zones that are not compatible with the Land Use Category.

Note: The following combining zones are compatible with all General Plan designations: FP, H, P, RD, SP, PD, PB, E, OS. The PUD combining zone is compatible with all "Residential" General Plan designations. The FW combining zone is compatible with all General Plan designations except "Residential".





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